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OUTDOOR WINTERING OF BEES

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INTRODUCTION

The beekeepers of the United States lose at least one-tenth of their colonies of bees every winter. This is a minimum loss, which is frequently increased to one-half and sometimes more in certain sections. This decrease is largly due to carelessness or to lack of knowledge, and it is entirely practical to reduce it to less than 1 per cent, the small loss covering various accidents which can not be foreseen. An industry which can survive in the face of such a decrease must have great possibilities for commercial advancement when the loss is properly reduced.

An important reason for the unnecessary death of colonies in winter is the belief of many beekeepers that, since unprotected colonies often live over winter, no protection is needed. When, for example, heavy insulation of bees is advocated at a beekeepers' convention, some beekeeper usually replies that he has never protected his colonies and never loses any. His reported success is often unintentionally exaggerated, and he indicates by such statements that he may not know what constitutes moderately successful wintering. Although probably nothing on a farm gives a better return on the investment than do bees if well cared for, the majority of beekeepers

NOTE.—This bulletin deals with the care of bees in winter when wintered outside and is of interest to beekeepers in al. parts of the United States.

neglect them. It need scarcely be stated that the best beekeepers do not follow such a parsimonious and unwise policy.

It is usually believed that winter loss is confined to the northern portions of the country, but this is far from true. The beekeepers of the South lose many colonies during this season, and, peculiarly enough, the decrease in all parts of the United States is due to the same causes in varying degree.

For the past three winters the authors[1] have made a study of the activity of bees during the winter and of the effects of various environmental factors on the colony. This bulletin does not include the results of this work, but gives the methods of outside wintering which have proved best in commercial apiaries, all the statements here made having been substantiated by the results of the more detailed studies which are to be reported in other form. There are many factors which require still more study and the doubtful points are not here discussed. It seems best not to include a discussion of the wintering of bees in cellars, concerning which there are many more points in dispute which can be settled only by detailed scientific studies. This omission should not be interpreted as indicating that the authors condemn cellar wintering; in fact, they are inclined to believe that when properly worked out this method will be found superior in northern localities.

Beekeepers usually report the results of wintering by giving the percentage of colonies in which all the bees die, just as was done in the first paragraph of this bulletin. This is a convenient method but is misleading. If every individual bee that goes into winter quarters remained alive in the spring with no loss of vitality, we should have perfect wintering, but such success is impossible. If out of 100 colonies only 2 die and the remainder are only half as strong in numbers as they were in the fall, most beekeepers would consider this rather good wintering, while in fact it is poor. The criterion of success is to save the greatest possible number of individual bees and to have them capable of prolonged activity in the spring. Beekeepers sorely need a new point of view as to success with this vital problem.

Frequently in beekeeping literature mention is made of the "winter sleep" of bees. Bees can not hibernate as do most insects. While the bees on the outside of the winter cluster are usually quiet, there is incessant movement in the center during cold weather; in fact, the colder the surrounding air, the greater the activity of the colony after a cluster is formed. The phrase "winter sleep" is

[1] For a preliminary report of this work see Phillips and Demuth, 1914. The temperature of the honeybee cluster in winter, Bul. 93, U. S. Dept. Agr., 16 p.

therefore erroneous and should be dropped from the literature, as it misleads beekeepers.

CAUSES OF WINTER LOSS

The causes of the death of individual bees or of a colony of bees in winter, barring unusual accidents, are only two in number: (1) Inadequate stores and (2) excessive heat production. The numerous factors usually given in the literature on the subject as entirely distinct fall into these two classes, except for some that are usually given which the authors do not believe to be operative.

EXCESSIVE HEAT GENERATION

It was first shown by the authors in the bulletin to which reference has been made that at hive temperatures between about 57° and 69° F. a normal broodless colony of bees does not form a cluster, but the bees remain inactive on the combs. When the temperature of the air immediately surrounding the bees (not the temperature of the air outside the hive) falls to 57° F. or lower, they form a cluster and those in the center begin to generate heat by muscular activity, while those in the outer portion serve as insulators by crowding close together, usually with their heads toward the center of the cluster. The innermost portion rapidly acquires a temperature considerably higher than that of the air about the bees before clustering was necessary, often going to 90° F. in normal colonies and higher in abnormal ones. The number of bees engaged in heat production increases as the outer temperature falls, and the insulating zone is consequently decreased in thickness but becomes more compact. The entire cluster becomes smaller as the outer temperature falls.

If bees can be kept in an environment such that the temperature of the air immediately surrounding them is 57° F. or slightly above, they are saved much unnecessary and unprofitable labor. To the theoretical objection that bees need exercise, it is necessary only to state that the authors have so wintered bees in a cellar as well as outdoors with wonderfully successful results. If bees are kept in a cellar under the best conditions the results are excellent, but it is not proposed to discuss this more complicated phase of the subject here. If wintered outside in a packing case with abundant insulation, any heat generated escapes slowly and the temperature of the air in the hive rarely falls below 55° F. If inadequately protected, the temperature of the hive can not be kept so high and the bees must generate much more heat. In single-walled hives it is common for the temperature of the air around the cluster to fall to freezing or lower, in which event the bees generate an excessive amount of

heat and perhaps die when they are no longer capable of the necessary muscular activity. The necessity of packing is thus made clear, and in any locality in which the outer temperature often falls to 40° F. or below it is desirable to protect bees to conserve their vitality. If the temperature should fall to 40° F. only a few times during the winter, this would not be serious enough to make insulation necessary. It is obvious, however, that winter protection is beneficial throughout practically the entire United States.

Necessity of having young bees.—Bees may be compared with minute dry batteries, in so far as their vital energy is concerned. They emerge as adult bees with a certain amount of vital energy, and when this is exhausted they die, not having power to recover lost vitality as human beings have. To withstand the hardships of winter under usual conditions, a colony must have many young bees, capable of prolonged muscular work. Obviously the better the wintering conditions, the less necessary it becomes to provide young bees, but even with the most perfect wintering it is desirable that there be plenty of young bees in the fall, so that they will be available for extensive brood-rearing in the spring. This calls for prolonged brood-rearing in late summer. Old bees, which have been worn out earlier and are ready to die, soon succumb from the work of heat-generation.

Danger of weak colonies.—In a strong colony many bees in the center of the cluster may be engaged in heat-generation, and there will still remain many bees to serve as insulators. A weak colony, on the other hand, has less reserves for insulation, and, since heat is rapidly lost, the bees on the inside must generate excessive heat in order that the outermost bees may always be at a temperature of over 50° F. Since the surface of a spherical cluster is proportionate to the square of the diameter, while the volume is proportionate to the cube of the diameter, it follows that a large colony cluster has a relatively smaller surface for radiation of heat than does a small one. Below about 50° F. individual bees become numb, and so long as the cluster remains active the authors have never found normal bees at a temperature lower than the critical temperature, 57° F. In a small colony the inner temperature is often many degrees warmer than that of a neighboring strong colony, which doubtless explains the prolonged brood-rearing of weak colonies in the fall. Most colonies which die of excessive heat-generation are rushed to their doom by the temperature being high enough to start brood-rearing, which is perhaps one of the most unfortunate circumstances which a colony can experience in winter. By all means a colony should be so protected that brood-rearing will not be begun until frequent flights are possible.

Since weak colonies so frequently succumb in winter, it is obvious that a too rapid increase in the number of colonies in summer is unwise. Beekeepers have learned that swarming is to be avoided because of the resulting reduction in the honey crop, and the loss in winter is additional argument against allowing the bees to exercise this instinct freely. It is a common saying among beekeepers that a rapid increase is usually followed by a rapid decrease. It is impossible to get too strong a colony for winter, the error always being in the opposite direction.

Effects of accumulation of feces.—It was first shown by the authors that heat-generation causes increased consumption of stores; this in turn causes an accumulation of feces within the bees, which is more rapid if the stores contain a high percentage of indigestible materials, and the presence of feces causes increased activity, often resulting in death from excessive heat generation. Beekeepers call this condition dysentery if the accumulation is so excessive that the bees are unable to retain the feces. Dysentery causes the death of bees in winter, so far as has been seen, solely by undue activity and excessive heat-production. This detrimental effect is reduced by good stores, but obviously the proper method is to prevent an unnecessary accumulation of feces by preventing a heavy consumption of stores, chiefly by providing a sufficiently high surrounding temperature. Honey-dew honey is especially injurious because of the rapidity with which feces accumulate.

In mild climates, in which there are frequent days when bees can fly and rid themselves of feces, the injurious effects of poor stores are less noticeable, because the feces do not accumulate sufficiently to cause abnormal activity. The accumulation of feces is to be considered as an irritant, causing responses similar to disturbance by jarring or exposure to light.

Influence of the queen.—In discussions of wintering it is usually stated that to winter well a colony must have a good queen. Obviously a good queen will better prepare a colony for winter by providing a strong colony of young bees than will a poor one, while a colony that is queenless in late summer and fall has little chance of living until spring. A good queen will also increase brood-rearing rapidly in the spring, if the colony has good stores and has been properly protected during the winter. Aside from the important influence on the population of the colony, the queen probably plays no part in wintering.

Spring dwindling.—If the individual bees of a colony are reduced in vitality by excessive heat-production, they may live until spring, but are unable to do the heavy work then needed to bring the colony back to full strength. The adult bees die more rapidly than they are

replaced by emerging bees, and the population decreases. This condition, which can be produced experimentally, has long been known among beekeepers as "spring-dwindling." If this condition is observed, the bees may perhaps be slightly relieved of further unnecessary work by packing to conserve heat and by giving abundant stores, but the proper treatment is to prevent the condition by proper care in the preceding fall and winter. The term "spring-dwindling" should not be applied to death of bees from other causes.

LACK OF STORES

A common cause of the death of colonies in winter is starvation, which is more certainly due to carelessness on the part of the beekeeper than is unnecessary heat-production. The greater the necessity for heat-production, the more necessary it becomes for every colony to have an abundance of stores of good quality. The amount required varies with the length of the winter, and also with the amount of heat which is generated. It is, of course, necessary also to provide or leave stores enough for brood-rearing in late winter or spring, before sufficient stores come to the hive from natural sources.

COMPARISON OF THE COLONY WITH A FURNACE

Let us assume that we have a furnace for heating a building so constructed that ashes may be removed only when the temperature of the outer air is warm. If the house has thin walls and many openings, the furnace can not maintain a high temperature in extreme cold weather, the amount of fuel consumed is increased, the ashes accumulate rapidly and clog the furnace, and in a desperate effort to raise the house temperature we should probably burn out the furnace. On the other hand, if the house is well built and heavily insulated, a low fire will suffice, and as a result there will be a minimum amount of ashes. The better the fuel the less the amount of ashes in either case.

It is permissible to compare a colony of bees as a unit of heat-production with this furnace. If the bees are in a single-walled hive in a cold climate, the colony must generate a great amount of heat, must consume much more honey, and feces will accumulate rapidly. As the bees are unable to discharge their feces until the temperature of the outer air is high enough for flight, the "furnace" is clogged. The bees are "burned out" by the excessive heat-production, and, even worse than in the case of the furnace, the irritation resulting from the presence of feces causes still more heat-production. On the other hand, if abundantly insulated, the heat generated is conserved, the consumption of stores and amount of feces are reduced, and the bees can readily retain the feces until a flight day, in any

place in which bees can be kept. The better the stores the less the amount of feces in either case.

We should not expect much of a furnace in an open shed, and we have no more right to expect good results from a colony wintered in a thin-walled hive in a cold climate, or even in a better hive placed in a windy location.

CONSERVATION OF HEAT AND REDUCTION OF EXPENDITURE OF ENERGY

In outside wintering the heat produced by the bees is conserved by the insulation of the cluster itself and also by the insulation of the hive and packing. In the cellar there is less insulation near the cluster, but the cellar itself replaces the packing, and is in reality simply an insulation. The insulation of the individual hive, of several hives packed together, or of bees in a cellar serves solely to reduce the loss of heat generated by the bees.

The amount of packing that should be used obviously varies with the climate and it is impossible to make definite general statements in a bulletin intended for all parts of the United States. There is one general statement which can be made with safety: The majority of beekeepers do not give sufficient insulation and no beekeeper ever gave a colony too much. For example, in the relatively mild climate of Washington, most beekeepers winter their bees in single-walled hives. The authors have used a large packing case holding four hives, two facing east and two west, close together. This case was constructed so as to hold 3 inches of packing below, 5 inches on the ends, 6 inches on the sides, and 8 to 12 inches on top. Colonies wintered in such a case in Philadelphia in 1913–14, and in the apiary of the Bureau of Entomology at Drummond, Md., near Washington, in 1914–15, were in much better condition than colonies left unprotected, and cases of this general type are being constructed for the entire apiary at Drummond, except for such colonies as are used in other wintering experiments. The dimensions here stated should by no means be accepted as best for other localities, especially those farther north, where the protection should be heavier, but in this particular packing case the temperature of the air within the hive but outside the cluster usually stood at about 55° to 57° F., except for a reduction in temperature under one condition to be discussed on the next page. The aim of the beekeeper should be to keep the air about the bees at about 57° F., at which temperature there is no condensation of moisture within the hive, even on the inside of the cover, where it first appears. It might be inferred that if double the amount of packing had been used the temperature of the air about the bees would have been too high. This is not the case,

for bees cease heat generation when the temperature reaches 57° F. (or even sooner when the surrounding temperature is rising[2]), and the temperature will not exceed 57° F. unless that of the outer air remains higher than that for a considerable period.

Bees well protected and with good stores do not fly from the hive because of the warmth within when the outer air is too cold for them to do so safely. If bees fly at low temperatures (45° to 50° F.), it is an indication that they need a flight because of an accumulation of feces from poor wintering, and does not at all indicate too high an inside temperature because of too much packing. In conclusion, the beekeeper can not apply too much insulating material to a hive.

It has been found that, even with abundant insulation, the temperature within the hive and outside the cluster is greatly reduced if the packing case is exposed to wind. During the winter 1914–15 a record was kept of wind velocity directly over a heavily packed case (with entrances ⅜ inch by 8 inches), and it was found that a wind with a velocity of 20 miles per hour directly on the case reduces the temperature within the hives practically to that observed in an unprotected hive. The beneficial effects of the insulation were therefore nullified, and the proper temperature within the hive was not regained for several days unless the outer temperature rose considerably. Beekeepers have long emphasized the importance of protection from wind, but the results observed were much more pronounced than was anticipated or than has ever been suspected by practical beekeepers. The ideal toward which the beekeeper should work is to keep his colonies during cold weather absolutely protected from wind, for here again the protection can not be too great. It is entirely erroneous to assume, as some have done, that such protection is not essential in well-packed hives.

There are several types of hives on the market in which the insulation is built in, to be retained throughout the year. There is no objection to the packing in the summer, except that such hives are not convenient for moving and in some other manipulations. Insulation in commercial double-walled hives is by means of air spaces or insulation, such as sawdust, chaff, broken cork, or shavings. These hives are better for outside wintering than single-walled hives in any part of the United States, but they do not provide adequate insulation at temperatures below about 40° F. Such hives must, of course, be protected from wind, or they are for the time being no better than single-walled hives.

Types of insulation.—Various materials are used for insulation. Beside those named above, paper, dry leaves, and many other substances are in use. Most of the common insulating materials depend

[2] See Department Bulletin No. 93.

on small confined dead-air spaces for their insulating value, and, in general, the more finely divided the air spaces the more efficient the material. Sawdust is usually condemned, because if moisture escapes from the hive into the packing it is retained and the insulating value is reduced. However, if a colony is sufficiently packed, moisture does not condense, except possibly at extremely low external temperatures, and this objection to sawdust is removed. From observations so far made, it appears that the beekeeper may use the materials most easily obtained. If dry leaves are used, they should be packed tight, but sawdust should simply be poured in place without being packed tight.

The entrance.—The weak places in hive insulation is the entrance. An opening 8 inches wide and ⅜ inch high is abundant, it usually being constructed as a tunnel through the packing. In cold weather this might be still further reduced. The opening should be shielded from the wind, to prevent a rapid loss of heat, for if the wind blows against the entrance the heat stored up in the packing is lost both to the outside and the inside. The only reason for an entrance as large as the size mentioned above is the danger that dead bees will drop from the combs and block a smaller entrance. Since the number of dead bees is greatly reduced in well-insulated hives this is less important, and, furthermore, if the air within the hive is warmed to 57° F. the dead bees will be pushed outside, even in freezing weather.

Methods of packing.—The exact method of packing is not especially important, provided enough insulation is given on all sides. Colonies may be packed singly in any sort of box, or they may be packed in groups of four, as previously described (p. 7). Some beekeepers arrange colonies in long rows and apply insulation to the whole row. The placing of several hives in contact has the advantage that the colonies insulate one another. If arranged in groups of four, two facing east and two west, they may be left on the same stand throughout the year and are readily manipulated during summer. If in long rows close together, summer manipulations are impeded, unless the hives are moved after the insulation is removed. Placing colonies in long rows is therefore not advisable. Whatever type of outer case is used, it should be tight, to prevent rain and snow from wetting the insulating material.

A rather common practice is to pack the hive at the sides, top, and rear, but to leave the front unprotected and faced to the south, the object being to utilize the heat of the sun to warm up the interior of the hive and reduce the work of the bees. Any place through which external heat may readily reach the interior of the hive is also efficient as an avenue through which heat may be lost when the sun is not shining. Since the sun shines less than half the time in winter,

making no allowance for cloudy days, the weakness of the argument for this practice is obvious. A similar practice is to paint the packing cases a dark color to absorb the sun's heat. Considerably more detailed work is needed to determine to what extent this source of heat is of value to the colony.

Time for packing.—At the time of the first killing frost the beekeeper should promptly remove supers, if any are on his hives. If the bees are not adequately supplied with good stores for winter these should now be given immediately, and, when the feeding is finished, the winter insulation should be applied at once. At this time bees are the quietest of any period of the year. The disturbance incident to putting on the insulation does not then do them any harm. After this the beekeeper should have no occasion to open the hive until spring. An outer temperature above 60° F. is desirable at the time of packing, especially if no brood is present. Any day when bees are flying is suitable.

If packing is delayed until late it may do far more damage than to leave the bees unpacked. A colony of bees that is generating heat in response to low temperature is considerably disturbed by the manipulations during packing and the temperature of the inside of the cluster is promptly raised. Frequently, if bees are packed too late (when it is too cold outside), the cluster temperature is raised to brood-rearing temperature, the queen begins to lay eggs, and brood-rearing is usually then continued through the winter, unless it results in the death of the colony, as is often the case. Many beekeepers pack their colonies in December with most harmful results. There is probably no place in the United States where packing is needed in which it is safe to wait later than Thanksgiving Day. Since more beekeepers make mistakes here than in any other phase of outside wintering, this should be emphasized most strongly. The authors have succeeded on several occasions in starting brood-rearing in December by manipulation, both in colonies wintered outside and in removing bees to a cellar, and it is certain that such winter brood-rearing is highly injurious to the colony.

Time for unpacking.—If a colony has a good queen and plenty of stores and is well packed, the beekeeper rarely has any reason for opening the hive until spring is well advanced. If he is not sure of the condition of the colony, he may wish to examine it earlier, but this first examination should be brief and the packing may be partially removed and replaced afterwards. If there are any queenless colonies or any colonies short of stores, these defects should, of course, be promptly corrected, after which the colony should remain undisturbed until, as the season advances, frequent manipulations are necessary. It is often best to leave the insulation on until

the colonies need more room, which will probably be as late as May 15 in the North. Colonies which have wintered poorly need their insulation longest, while colonies that have been well insulated, either in a cellar or outside, can, if necessary, stand considerable exposure without much damage, although the work of heat-generation thereby reduces the energy available for building up the colony rapidly.

The time for removing packing may be still further delayed by wintering a colony outside in 2-hive bodies, the upper one being well supplied with honey. Since there is more space to keep warm, such a hive should be more thoroughly insulated. If this plan is followed, the beekeeper is sure that sufficient stores are available and he can properly locate any queenless colonies by a brief external examination. Since wintering in 2-hive bodies has not been practiced extensively, it should be tried with caution, but reports of this method should be available from all parts of the country and beekeepers are urged to try it on an experimental scale. The plan has much to commend it.

Providing a windbreak.—It is well established that a windbreak of evergreens is superior to a solid windbreak such as a house or solid fence. The beekeeper can readily determine whether his bees are located in a place where the wind rarely or never blows more than 5 miles an hour in winter. If the apiary is not so located, it should be moved during the summer to a place in the woods, in a gully, or in some other sheltered place. Bees should never be moved in winter. If it is not practicable to move the apiary, a high fence, perhaps 8 feet high, should be constructed on the exposed sides. The more compact the apiary, the easier it is to construct a windbreak, which is an argument for placing colonies in groups of four. Evergreens are slow growing, and a high fence may be used until the permanent windbreak is sufficient. If the apiary is practically surrounded by buildings, this may be adequate protection, but such a location is usually not the most convenient for the apiary. A southern exposure is usually recommended as best for winter, for it is claimed that the heat of the sun is beneficial. Since the sun shines only a small fraction of the time in winter in most localities, especially in the East, where there is much cloudy weather, this feature should not be unduly emphasized.

PROVIDING ADEQUATE WINTER STORES

The amount of honey that a colony will need from the time it is packed until it is unpacked can not be closely estimated. The aim of the beekeeper in winter should be to save bees rather than honey, and he can make no more profitable investment than to give his bees more than they can possibly use. Some beekeepers claim that

it is best to have the old bees die soon, so as to save stores. The actual consumption in such badly wintered apiaries is probably not at all decreased.

If the bees do not have sufficient stores, they may be given combs of honey, but these should always be given before cold weather, so that a proper clustering space may be formed by the moving of honey, since bees always cluster in empty cells of the comb adjacent to stores.

If honey in combs is not available, the bees may be fed extracted honey, but the usual practice is to feed a thick sugar sirup made of 2 or 2½ parts of sugar to 1 part of water by volume. To this sirup 1 ounce of tartaric acid should be added for each 40 to 60 pounds of sugar while the sirup is being heated to the boiling point to dissolve the sugar crystals. The sirup should be boiled 15 minutes. The acid helps to invert the cane sugar, thus retarding its granulation in the combs. If there is any question as to the quality of the stores, it is a good practice to feed about 10 pounds of sirup at the time of packing, in addition to the stores provided earlier, this being stored immediately above the cluster. It is thus used first, and an accumulation of feces does not occur so long as the bees use only the sugar sirup. There is, however, no better food in winter than a good quality of honey. As was stated earlier, honey-dew honey causes a rapid accumulation of feces, resulting in dysentery, If this is present in the fall, it should be removed and better stores given. Some fall honeys are similarly injurious, but their injurious effects may be reduced by feeding sirup at the time of packing.

SUMMARY AND CONCLUSIONS

Bees need protection from cold and wind in winter in practically all parts of the United States. The beekeeper should give abundant insulation, since it is impossible to give too much and since most beekeepers give too little. Great care should be exercised to protect colonies from wind. Every colony should be strong in the fall, so that heat may be generated and conserved economically. To reach the proper population a good queen is necessary.

Many colonies die of starvation in winter. This can easily be avoided.

The beekeeper can make no better investment than to give his colonies proper care for winter.

If the excessive winter losses are prevented, commercial beekeeping will be greatly benefited. Such a condition is entirely possible when beekeepers come to understand the fundamental principle of wintering.

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